Impact of Variations in Renewable Generation on California's Natural Gas Infrastructure

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Research Purpose

- To explore the impact of variations in renewable power generation on California's ***natural gas*** infrastructure.
  - Impact on gas-fired power generation
- Project the adequacy of California's natural gas pipeline and storage to meet a peak day (January) in 2020.
- ICF modeled California natural gas infrastructure in 5 different scenarios for meeting a 33% Renewable Portfolio Standard (RPS) by 2020.
  - Varied weather conditions
  - Varied renewable generation mix
  - Varied amount of solar and wind generation available

Assumptions

- Power assumptions were based on 33% RPS scenarios developed by the CPUC for the 33% Implementation Analysis Working Group Meeting on January 15, 2009.
  - Renewable generation mix (Reference, High Wind, High Central Station Solar).
  - Electricity demand growth rate is consistent with the CEC's 2007 projection of 1.1% per year growth through 2020.

- Other natural gas assumptions based on ICF's January 2009 Base Case:
  - Residential, commercial, and industrial gas demand
  - Natural gas pipeline and storage infrastructure additions.

Case Descriptions

1) **33% RPS Reference Scenario,**
   Expected Renewable Generation
   Normal Weather.

2) **33% RPS Reference Scenario,**
   Expected Renewable Generation,
   Adverse Weather - Colder Winters / Hotter Summers.

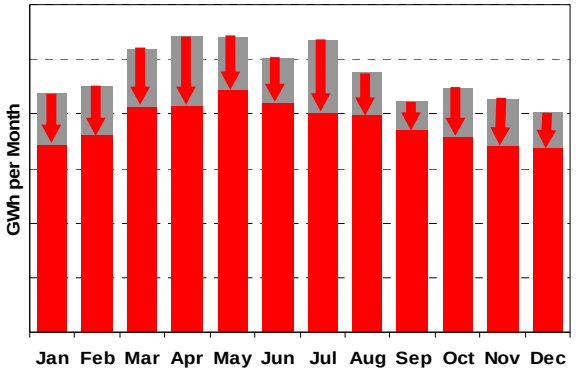
3) **33% RPS Reference Scenario,**
   Reduced Renewable Generation (Solar and Wind) – Increased Gas Generation
   Adverse Weather - Colder Winters / Hotter Summers.

4) **33% RPS High Wind Scenario,**
   Reduced Renewable Generation (Solar and Wind) – Increased Gas Generation
   Adverse Weather - Colder Winters / Hotter Summers.

5) **33% RPS High Central Station Solar Scenario,**
   Reduced Renewable Generation (Solar and Wind) – Increased Gas Generation
   Adverse Weather - Colder Winters / Hotter Summers.

Modeling of Reduced Renewable Generation Cases

Projected 2020 Renewable Generation for "Reduced Generation" Case



Changes in Renewable Generation

GMM

Solves for regional gas demand, gas prices, inter-regional pipeline flows, and regional storage activity

Reduced renewable generation increases power sector gas consumption

Monthly Gas Load

DGLM

Solves for Daily Gas Load

Reduced renewable generation increases on-peak gas consumption

Daily Gas Load

Gas prices, regional consumption, regional production, and inter-regional pipeline flows

RIAMS (Daily)

Solves for peak day intra-regional pipeline flows, and field-level storage activity

Increased gas consumption increases peak day pipeline flows and storage activity

Peak month storage activity

RIAMS (Monthly)

Solves for monthly average intra-regional pipeline flows and field-level storage activity

Increased gas consumption increases intra-regional pipeline flows and storage activity

California's Projected Electric Generation

California Electricity Generation, TWh/year	2007	2008	2009	2010	2015	2020	2008-20 Delta	2008-20 CAGR
Gas	117	121	101	100	102	90	(31)	-2.5%
Oil	4	4	4	4	4	4	(0)	-0.4%
Coal	2	3	3	3	3	3	-	0.0%
Large Hydro	25	21	26	31	31	31	10	3.2%
Nuclear	36	35	37	35	38	37	1	0.3%
Renewables	28	31	34	37	61	85	54	8.8%
Total	**213**	**216**	**204**	**210**	**238**	**249**	33	1.2%
Net Electricity Imports	**92**	**93**	**94**	**95**	**100**	**104**	11	0.9%
Renewables Imports	*7*	*8*	*9*	*10*	*14*	*18*	*10*	*7.1%*
Net Energy for Load	**306**	**309**	**298**	**305**	**338**	**353**	44	1.1%
Total Renewables	**36**	**39**	**42**	**47**	**75**	**103**	64	8.5%
Retail Electricity Sales	**263**	**268**	**258**	**261**	**292**	**309**	42	1.2%
Renewables as %	*14%*	*15%*	*16%*	*18%*	*26%*	*33%*		

1. Actual data as reported by EIA and CEC assumed through 2008

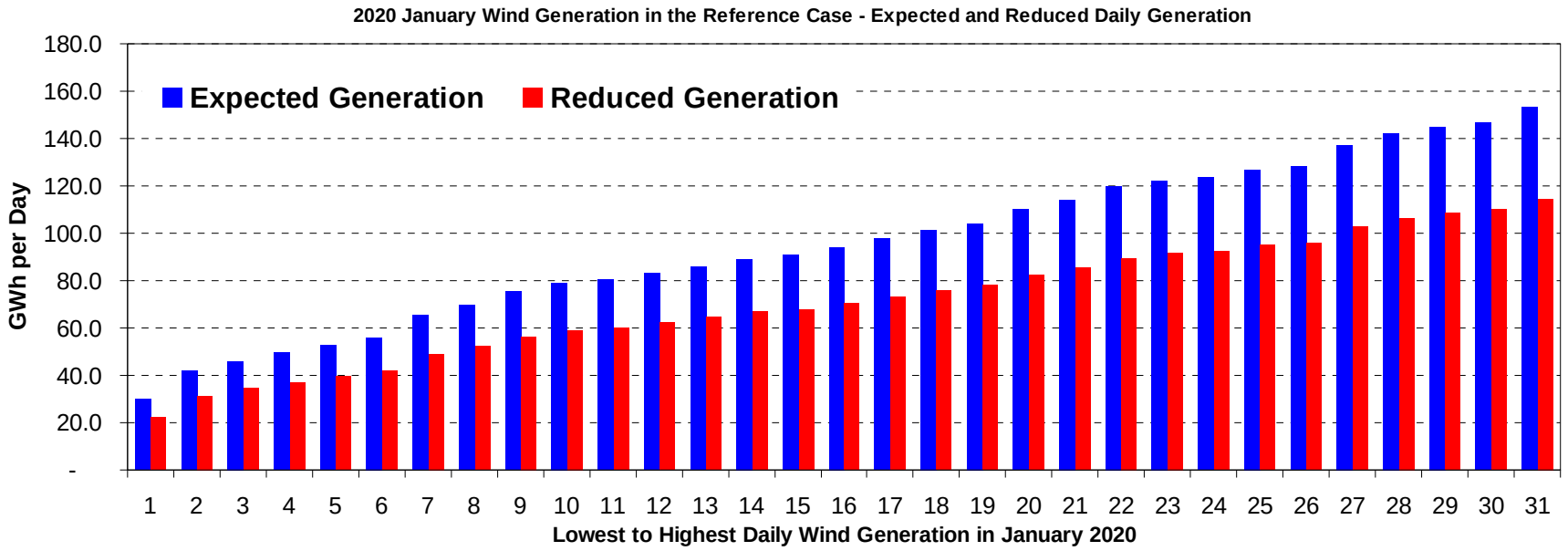
33% RPS Scenarios: Expected Generation in 2020

Generation in GWh per Year	2008 Base Generation /1	Reference Incremental Increase	Reference Total Generation	High Wind Incremental Increase	High Wind Total Generation	High Central Station Solar Incremental Increase	High Central Station Solar Total Generation
Wind	5,724	32,685	38,409	42,849	48,573	31,057	36,781
Solar (PV and Thermal)	724	24,815	25,539	11,448	12,172	26,383	27,107
Biomass	5,696	3,050	8,746	4,756	10,452	3,110	8,806
Biogas	-	2,078	2,078	2,078	2,078	2,078	2,078
Geothermal	12,951	11,520	24,471	13,034	25,985	11,520	24,471
Small Hydro	3,761	116	3,877	100	3,861	116	3,877
Total RPS Generation	28,856	74,264	103,120	74,264	103,120	74,264	103,120

Reduced Generation in 2020

	Reference GWh	Reference % Reduction	High Wind GWh	High Wind % Reduction	Solar GWh	Solar % Reduction
Wind	29,352	-24%	37,119	-24%	28,108	-24%
Solar (PV and Thermal)	23,594	-8%	11,245	-8%	25,043	-8%
Biomass	8,746	0%	10,452	0%	8,806	0%
Biogas	2,078	0%	2,078	0%	2,078	0%
Geothermal	24,471	0%	25,985	0%	24,471	0%
Small Hydro	3,877	0%	3,861	0%	3,877	0%
Total RPS Generation	**92,119**	**-11%**	**90,741**	**-12%**	**92,383**	**-10%**

Example of Reduced Daily Wind Generation Reference RPS, Expected versus Reduced Generation



- **For the Reduced Generation cases, we assume a "stress" scenario, in which the lowest wind generation day in January occurs on the highest gas demand day in January.**
  - **This increases peak day gas demand during the highest gas demand month of the year.**

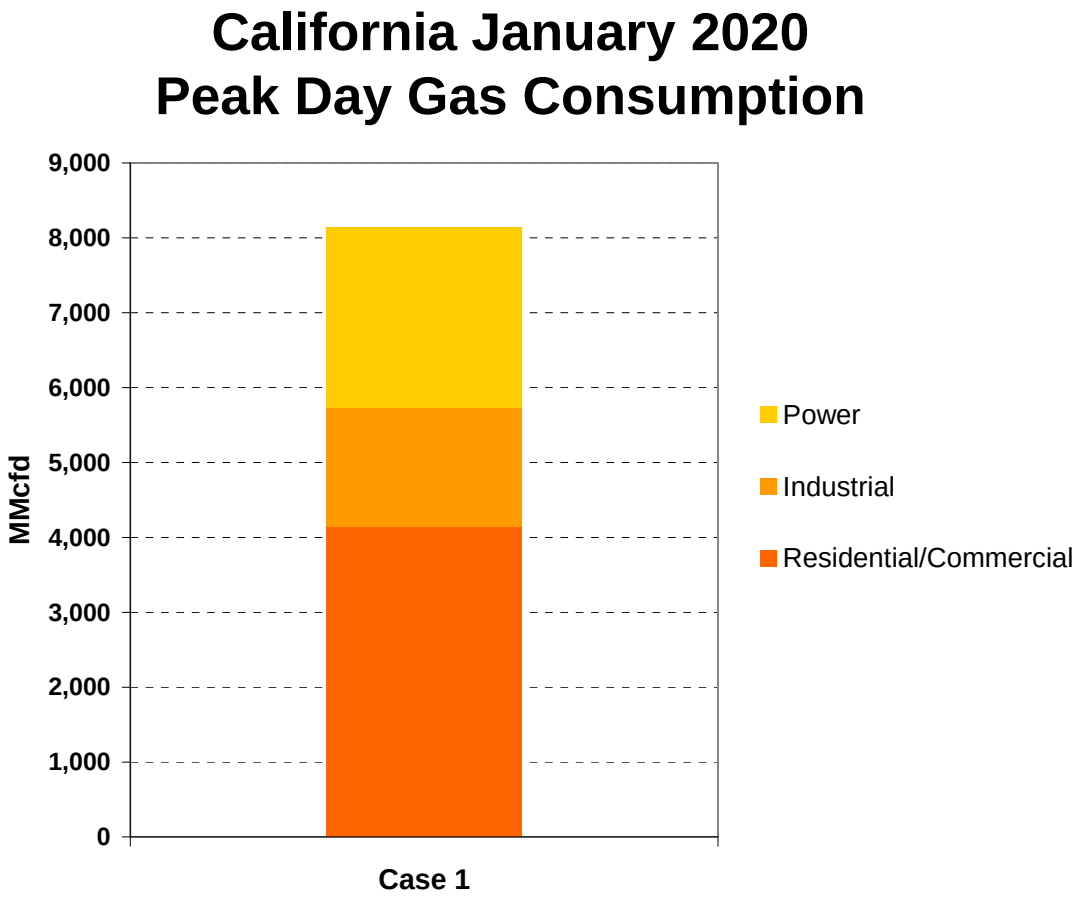
California Gas Balance: Average Annual Day

Case 1: 33% RPS Reference Case, Expected Renewable Generation, Normal Weather

Bcfd	2008	2009	2010	2015	2019	2020	2008-20 Delta	2008-20 CAGR
Consumption	**6.29**	**5.58**	**5.69**	**5.66**	**5.44**	**5.39**	(0.9)	-1.3%
Residential	1.43	1.31	1.34	1.30	1.29	1.29	(0.1)	-0.8%
Commercial	0.67	0.66	0.66	0.65	0.65	0.66	(0.0)	-0.2%
Industrial	1.48	1.35	1.45	1.48	1.50	1.50	0.0	0.1%
Power Generation	2.58	2.13	2.11	2.10	1.86	1.81	(0.8)	-2.9%
Other	0.13	0.13	0.12	0.13	0.13	0.13	(0.0)	-0.4%
Pipeline Exports	**0.07**	**0.08**	**0.10**	**0.03**	**0.09**	**0.09**	0.0	1.6%
To Northern Nevada	0.07	0.08	0.10	0.02	0.02	0.02	(0.1)	-10.4%
To Mexico	-	-	-	0.02	0.07	0.07	0.1	n/a
Production	**0.88**	**0.87**	**0.84**	**0.83**	**0.85**	**0.85**	(0.0)	-0.4%
Pipeline Imports	**5.61**	**4.94**	**5.03**	**4.91**	**4.72**	**4.67**	(0.9)	-1.5%
via Southern Nevada (Kern River)	1.54	1.52	1.53	1.87	1.87	1.87	0.3	1.7%
via Arizona (El Paso, Transwestern)	2.82	1.93	2.01	1.84	1.60	1.58	(1.2)	-4.7%
via Malin	1.23	1.48	1.45	1.18	1.25	1.21	(0.0)	-0.2%
via Mexico (Costa Azul LNG)	0.02	-	0.04	0.02	0.00	0.01	(0.0)	-7.0%
Storage Net Injections / (Withdrawals)	**0.02**	**0.09**	**0.02**	**-**	**-**	**-**	(0.0)	-100.0%
Balancing Item	**0.11**	**0.07**	**0.06**	**0.05**	**0.04**	**0.04**	(0.1)	-8.8%

Case 1: 33% RPS Reference Scenario with Expected Generation and Normal Weather (continued)

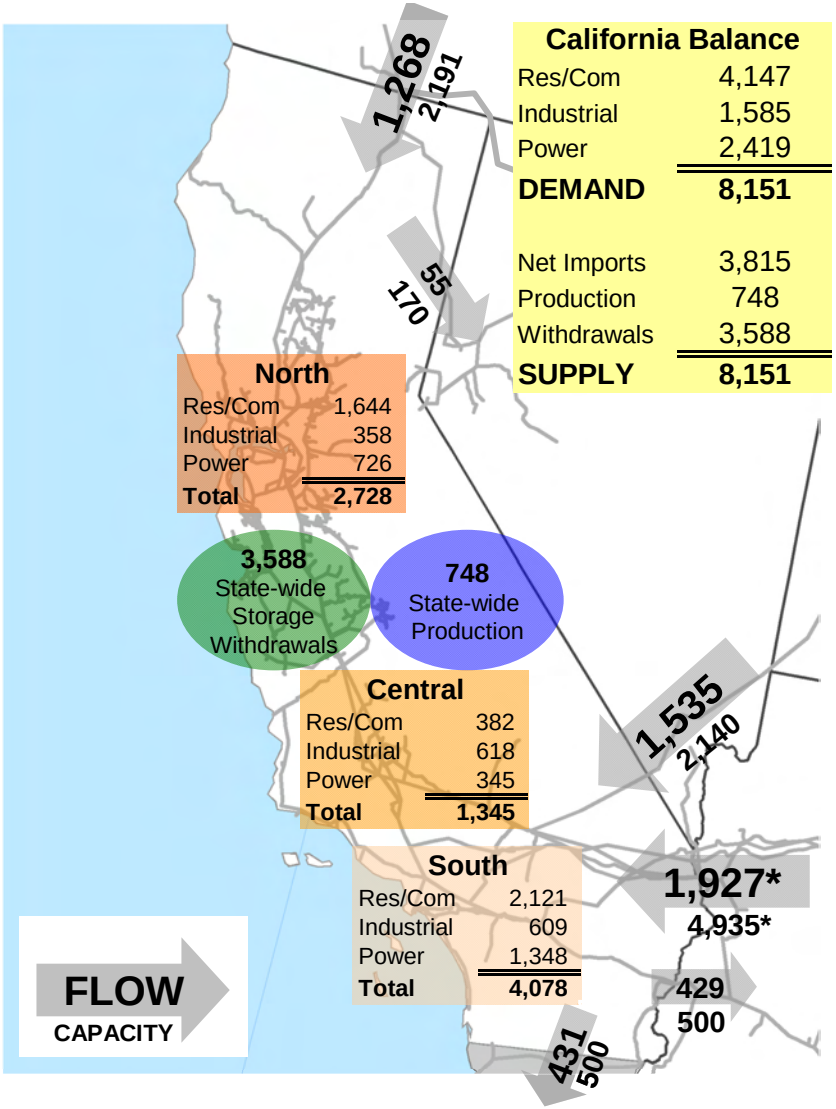
- Under normal weather conditions, peak day gas consumption is projected to be 8.2 Bcf, about 20% greater than the peak month average and over 50% greater than the annual average.
- About 50% of the peak day consumption in the residential and commercial sectors, 30% is for power generation, and 20% is for industrial uses.



Case 1: 33% RPS Reference Scenario with Expected Generation and Normal Weather (continued)

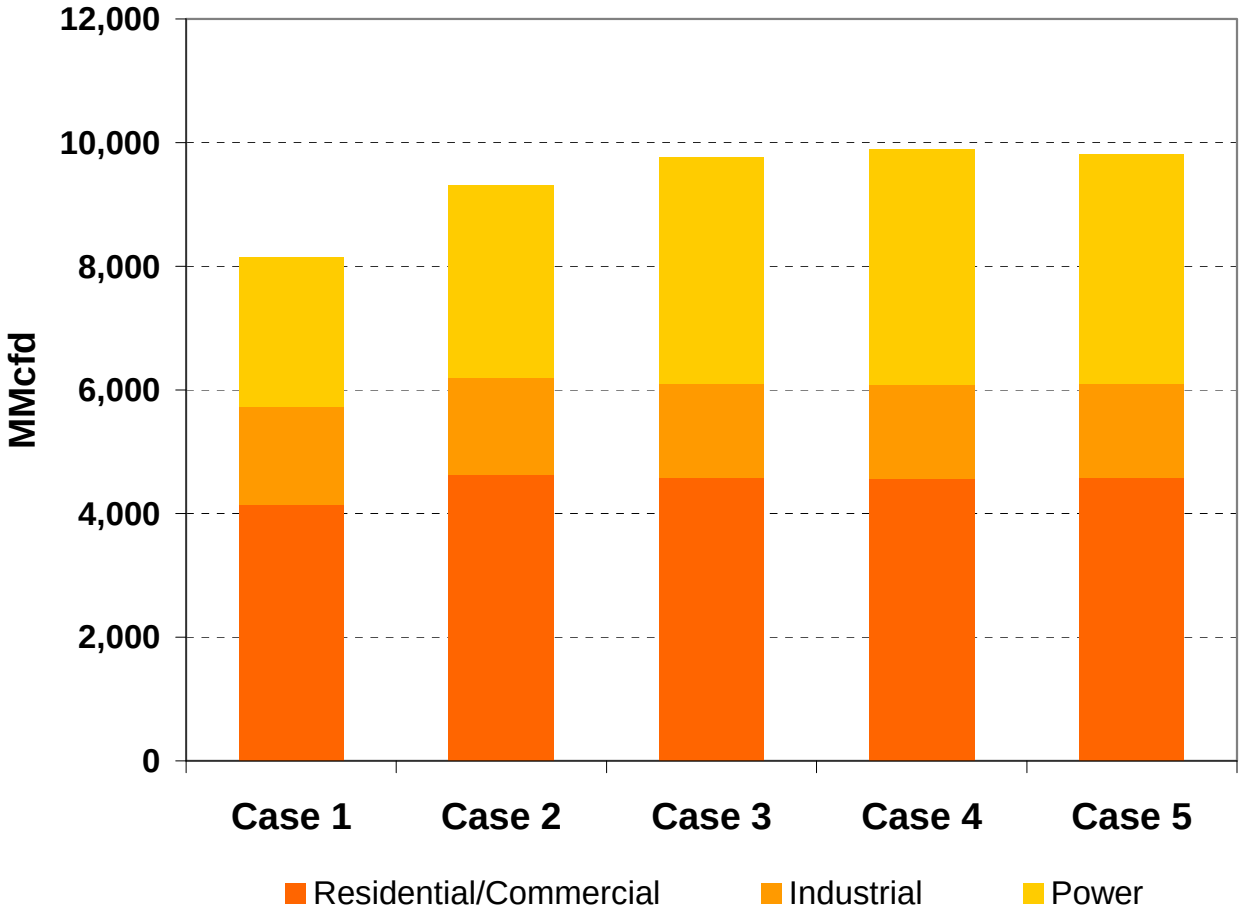
- On the peak gas demand day in January, about 50% of the total demand, and 55% of the power sector demand is in Southern California.
- 47% of peak day demand is met by pipeline imports, 44% by storage withdrawals, and 9% by in-state gas production.

Case 1: January 2020 Peak Day Balance (MMcfd)



* Total of El Paso, Transwestern, and Southern Trails

Case 1: 33% RPS Reference Scenario with Expected Generation and Normal Weather (continued)



Summary of Results

- A 33% RPS leads to declining gas demand in California
  - Even assuming adverse weather and hydroelectric conditions in 2020, total gas consumption is still projected to be lower in 2020 than it was in 2008.

- Reduced renewable generation is not enough to cause significant problems for the State's gas pipeline or gas storage infrastructure.
  - All the reduced renewable generation cases resulted in an incremental increase in peak day gas demand of about 0.5 Bcfd (or 6%),

- Technology mix and geographic diversity in renewables minimizes the potential impact of reduced renewable generation.

Caveats

- This analysis is based on the CEC's 2007 projection of 1.1% per year growth in California's electric load.
- The estimates for wind and solar variability are based on a limited amount of data, so the potential variability in generation may be more or less than represented in this study.
- This analysis assumes that reductions in RPS generation within an area (Northern, Central, or Southern California) will be met with increased gas-fired generation in the same area.
- The pipeline analysis is based on a county-level assessment of mainline capacities, storage field locations, and gas demand.
- This analysis focuses on seasonal and daily variations in renewable generation; the impact of hourly variations has not been assessed.

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